PHYSICS OF OFFSHORE BURIED MINE DETECTION FOR A BROAD RANGE OF SEDIMENTS

Nicholas P. Chotiros
Applied Research Laboratories
University of Texas at Austin, TX 78713-8029
phone: (512) 835-3512 fax: (512) 835-3259 email: chotiros@arlut.utexas.edu
Award #: N00014-95-1-0499

LONG-TERM GOAL

A better understanding of the science and engineering of buried mine detection leading to safe, standoff detection technologies.

SCIENTIFIC OBJECTIVES

A unified model of acoustic penetration of ocean sediments for a wide variety of sediment types, from gravel through sand, silt and clay and combinations thereof, and a model of signal attenuation and reverberation due to multiple scattering by sediment grains.

APPROACH

The approach is based on the premise that a physically sound model of sediment acoustics must be consistent with all known sediment acoustic measurements, including scattering, reflection and transmission at the water-sediment interface, and propagation speed and attenuation of all relevant waves within the sediment. In modeling acoustic penetration into and propagation within ocean sediments in the context of Biot's theory, for a wide variety of sediment types, the most illusive unknowns are the grain and frame moduli and the permeability. The relationship between the frame bulk modulus and porosity, and the effects of bioturbation, can only be established by collecting acoustic reflection and penetration data along with geophysical data from a wide range of sediment types. Measurements of fast, slow and shear waves, and sediment porosity are particularly important. In this effort, collaboration with the SACLANTCEN has proven to be mutually beneficial. A physically sound model of the intrinsic acoustic scattering process is more difficult because it is beyond Biot's theory of sound propagation in porous media. A numerical code for modeling multiple scatter within a granular medium, based on random pore size variations, is the only working model at present. This model has been extensively exercised and it has revealed a number of interesting properties of granular media, above and beyond Biot's theory.

RESULTS

In accordance with the stated approach, the results include a variety of measurements and their analyses. Taken together, they lead towards a coherent and comprehensive model of sediment acoustics. Bottom reflection measurements made in a joint experiment with

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Physics of Offshore Buried Mine Detection for a Broad Range of Sediments**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Texas at Austin,Applied Research Laboratories,Austin,TX,78713**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

SACLANTCEN over gassy and non-gassy sediments were processed for reflection loss. The results from the gassy site suggest that acoustic bubble interactions account for a significant part of the sound energy returned and the spectral content suggests nonlinear processes[1]. Shallow grazing angle bottom penetration measurements made in another joint experiment with SACLANTCEN in a silty sand sediment were re-analyzed for sediment wave properties, including speed, attenuation and dispersion[2]. The results show the fast wave to be highly dispersive in the 1 to 10 kHz band, which is consistent with a new sub-model which treats the frame as a partially fluid-supported structure[3], in which a proportion of the frame compressional stress at the grain-grain contact is carried by a film of fluid. This sudmodel, though still controversial, will shed new light on the role of the pore fluid in controlling the apparent grain and frame moduli of unconsolidated granular media. Regarding the scattering problem, although little progress has been made in the search for a suitable analytical model of multiple scatter in a Biot medium, the numerical code, based on random pore size variations, has proved to be very useful. Results show that scattering strengths approaching that of gas-free water-saturated sands in the laboratory are achievable[4]. The current bottom scattering model, called BOGGART version 3.0, which is based on Biot's theory but using a diffusion approximation for the multiple scattering process, was compared to torpedo sonar reverberation data measured by NUWC. Although initial results were less than satisfactory [5], the latest result, which took into account the effect of surficial rocks in the test site, was very encouraging[6]. The reverberation is intimately connected with sediment acoustic modeling because, in addition to the scattering strength, the reverberation level and its variation with time are dependent to a large extent on the forward reflection loss of the sediment.

IMPACT/APPLICATION

The final result will lead to a comprehensive acoustic model that will be valid for a wide range of sediments, and form the foundation of buried target detection and classification models over a broad range of sediment types.

TRANSITIONS

The results are directly relevant to the modeling of sediment acoustic processes and the prediction of mine hunting sonars, not just against proud and tethered mines, but also against buried mines. They are being transitioned into the bottom scattering model BOGGART.

RELATED PROJECTS

The work is related to numerous projects in sediment acoustics because it cuts to the heart of the fundamental physical mechanisms of reflection, transmission, propagation and scattering.

REFERENCES

[1] F. A. Boyle, N. P. Chotiros, N. G. Pace, O. Bergem, and E. Pouliquen, Analysis of broad-band echosounder data over a gassy seabed. High Frequency Acoustics in Shallow Water, N. G. Pace et al. (Ed.), pp. 49-56, CP-45, NATO SACLANT Undersea Research Centre, La Spezia, Italy, 1997.
[2] N. P. Chotiros, A. M. Mautner, A. Løvik, Å Kristensen, O. Bergem, Acoustic penetration of a silty sand sediment in the 1 to 10 kHz band. IEEE J. Oceanic Eng., in press
[3] N. P. Chotiros, A. M. Mautner, An idealized model for the frame elasticity of sand. J. Acoust. Soc. Am. 100(4), Pt. 2, 2765, Oct. 1996.
[4] D. J. Yelton, M. Stern, Morris, N. P. Chotiros. A model of acoustic scattering by granular, poroelastic ocean sediments. submitted to J. Acoust. Soc. Am.
[5] R. E. Keenan, H. Weinberg, F. E. Aidala Jr. Modeling range-dependent, high-frequency, shallow-water torpedo reverberation data. High Frequency Acoustics in Shallow Water, N. G. Pace et al. (Ed.), p. 291-297, CP-45, NATO SACLANT Undersea Research Centre, La Spezia, Italy, 1997.
[6] R. E. Keenan, Response to Ser ASD-97-72, "Likely causes of discrepancy". private communication, 16 September 1997.